PROPULSION DIRECTORATE

Monthly Accomplishment Report
December 2005

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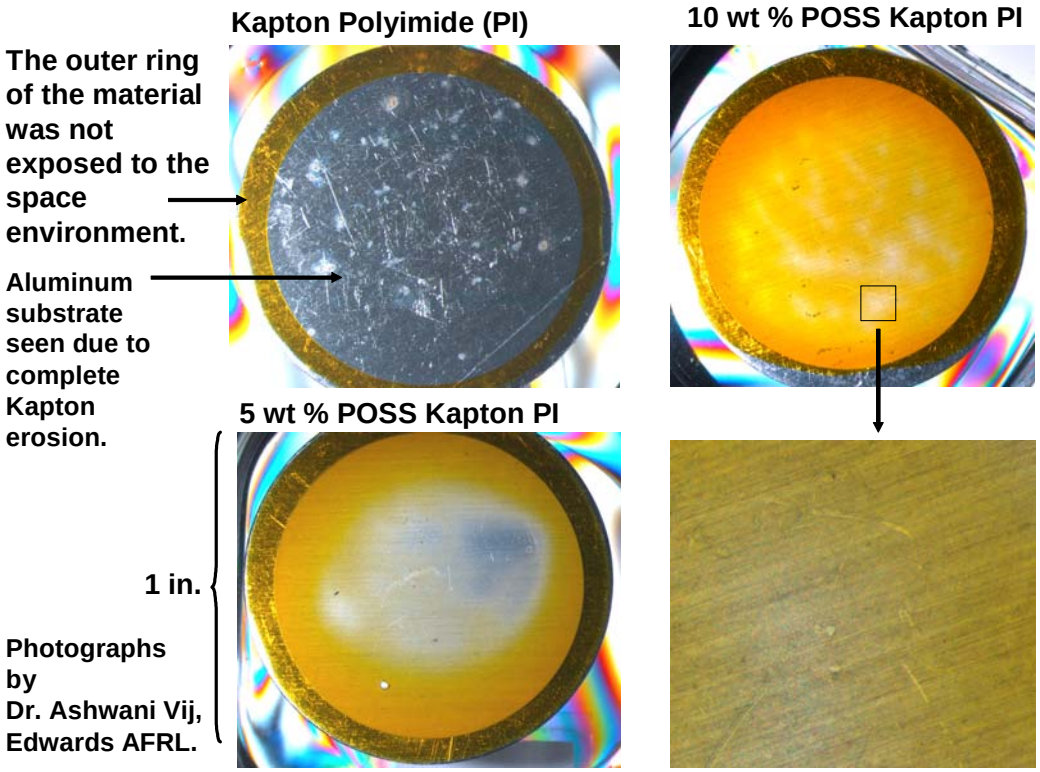
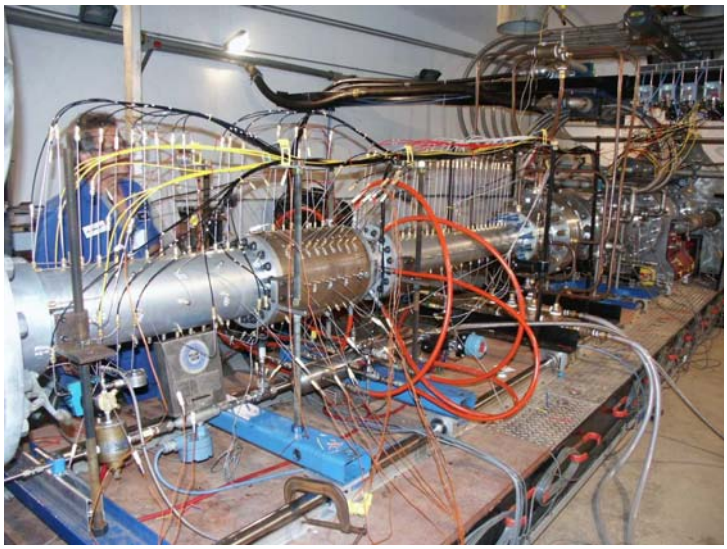
POSS MATERIALS DEMONSTRATE ABILITY TO SURVIVE IN SPACE: The Propulsion Directorate's POSS* -Polyimide Space Survivable Polymers program strives to synthesize and develop multifunctional space-survivable materials. The current goal of this DARPA-funded program is the fabrication of a survivable, drop-in replacement for the ubiquitous but short-lived Kapton® material currently used in many space applications. Kapton® polyimide is used extensively on spacecraft primarily as a flexible substrate for lightweight solar arrays, in multi-layer insulating blankets, and in space inflatable structures. It has been well established that polymeric materials and films undergo severe degradation as a result of the aggressive environment encountered in low Earth orbit (LEO), predominantly due to high fluxes of atomic oxygen (AO). In certain LEO environments, Kapton® can completely degrade within one year. Several POSS-containing polymer samples, including POSS Kapton® polyimides, were flown on the International Space Station for nearly four years as part of the Materials International Space Station Experiment (MISSE1). These samples were returned to Earth on the Space Shuttle, and AFRL/PR's Dr. Tomczak is the lead for the analysis of the POSS-containing polymer samples. Kapton® polyimide containing no POSS completely eroded, 5 wt % POSS polyimide showed some survival, and 10 wt % POSS polyimide film remained. These results were anticipated from ground-based simulated low Earth orbit exposures carried out at Montana State University. For 10, 20, and 25 weight % POSS polyimide samples, these tests resulted in erosion yields of 3.7, 0.98, and 0.3 percent, respectively, of the erosion yield for Kapton H. The dramatically reduced erosion yields result from a self-passivating silica layer that forms upon AO exposure and protects underlying POSS polyimide. While the surface and physical properties of the samples remain to be characterized, the space survivability of POSS polymers has now been demonstrated in a space flight experiment. (Dr. S. Tomczak, AFRL/PRSM, (661) 275-5171)



* POSS = polyhedral oligomeric silsesquioxanes

TEST EXPERIMENTS OF ROUND SCRAMJET COMBUSTOR SUCCESSFULLY COMPLETED: Working under the Propulsion Directorate's Robust Scramjet Program, Aerojet successfully completed the initial series of tests of a Round Scramjet combustor. Testing was conducted at Aerojet's facility in Orange, Virginia, at enthalpies equivalent to Mach 2.7 to Mach 5 flight. The objective of this research was to demonstrate technologies that can be used to increase operability of scramjet engines. Also, this effort sought to obtain a baseline data set for the scaling of structurally efficient round combustors for engines suitable for access-to-space applications. Round combustor geometries are favored due to their ability to withstand high internal pressure. Furthermore, by eliminating corner effects inherent in two-dimensional (2-D) geometries, the surface area and overall weight of the combustor can be reduced. Another test entry of this combustor is planned for later in 2006 to obtain additional baseline data, which will help pave the way for the development of larger combustors. (Dr. C. Raffoul, AFRL/PRA, (937) 255-7317)



Aerojet's round scramjet combustor test rig (top) and the rig in operation (bottom)

DR. BORGER HONORED FOR OUTSTANDING SERVICE WITH TWO AWARDS: Dr. William U. Borger, Director of the Propulsion Directorate, was recently honored with two awards. Dr. Borger received the prestigious Decoration for Exceptional Civilian Service. This award, which recognizes exceptionally distinguished service and accomplishments with significant Air Force-wide scope and impact, is the highest Air Force recognition granted to civilian employees. This award recognizes Dr. Borger's national leadership and technical expertise while serving as the Director of AFRL's Plans and Programs Directorate (AFRL/XP) from March 2002 to May 2005. In this role, his focused leadership, professionalism, and tireless efforts fostered crucial communications between the primary services and the DoD in coordinating the nation's science and technology program to assure maximum technology development for the nation's warfighters. In addition, Dr. Borger also recently received the Office of the Secretary of Defense (OSD) Award for Excellence. Dr. Borger earned this award for his superior performance on the DoD Base

AFRL/PR Director, Dr. William Borger, recently received both the Decoration for Exceptional Civilian Service and the OSD Award for Excellence

Dr. Fred Schauer was recently granted a US Patent on pulsed detonation engines

Realignment and Closure (BRAC) Technical Joint Cross Service Group, Innovative Systems Panel, and Enabling Technologies Panel from September 2003 to May 2005. As the lead Air Force member on these panels, Dr. Borger provided the OSD Technical Joint Cross Service Group critical vision and insight into the AFRL infrastructure and business models. (Mr. J. Pearce, AFRL/PRA (UTC), (937) 255-5015)

PULSED DETONATION ENGINE PATENT GRANTED: On 27 December 2005, the Propulsion Directorate's Dr. Frederick R. Schauer was granted US Patent No. 6,978,616 titled "Hybrid Piston-Pulsed Detonation Engine." This patent describes a hybrid piston engine-pulsed detonation engine (PDE) where the piston engine is operatively connected to the PDE for the purpose of extracting shaft power. Traditionally, the PDE has been viewed as a thrust-producing engine. However, for the PDE to perform satisfactorily in most commercial applications, such as in commercial passenger jet airliners, a second engine for power extraction from the PDE would be required to run subsystems such as lights and air conditioning. Consequently, this patent addresses the need for a PDE that can generate *both* thrust power and shaft power. This concept has been successfully demonstrated as described in the paper titled, "Evaluation of a Hybrid-Piston Pulsed Detonation Engine."[†] (Dr. F. Schauer, AFRL/PRTC, (937) 255-6462)

INTEGRATED POWERHEAD DEMO TEAM WINS JANNAF AWARD: The Integrated Powerhead Demonstration (IPD) Engine System Test Team was recently honored by JANNAF. At the 53rd JANNAF Propulsion Meeting/2nd Liquid Propulsion Subcommittee (LPS)/1st Spacecraft Propulsion Subcommittee

[†] Frankey, B., Schauer, F., Bradley, R., and Hoke, J., "Evaluation of a Hybrid-Piston Pulsed Detonation Engine," AIAA Paper 2002-0474.

The IPD team won the LPS Outstanding Achievement in Liquid Propulsion Award. Pictured (from L to R) are: Harry Ryan, NASA SSC; Stephen Hanna, AFRL/PR; Fernando Vivero, Pratt & Whitney Rocketdyne; Grant Hart, Aerojet; Gary Genge, NASA MSFC; and (back row) LPS Awards Chair Chris Protz, NASA MSFC.

(SPS) Joint Meeting held in Monterey, California, in December 2005, the Liquid Propulsion Subcommittee presented the team with the prestigious Outstanding Achievement in Liquid Propulsion Award. The IPD team was recognized for its outstanding skill and innovation in successfully demonstrating the Full Flow Staged Combustion (FFSC) engine cycle for the first time in the United States. The IPD Program addresses the DoD/NASA Vision and commercial needs to dramatically increase safety and reliability of rocket engine systems for reusable launch vehicles while reducing the cost. Through the use of the FFSC cycle, the IPD engine can achieve life and reliability 10 times greater than the Space Shuttle Main Engine. The Propulsion Directorate's Mr. Stephen Hanna, the IPD Program Manager, was a member of the award winning team, along with representatives of NASA Stennis Space Center (SSC), NASA Marshall Space Flight Center (MSFC), Aerojet, and Pratt & Whitney Rocketdyne. (Mr. S. Hanna, AFRL/PRSE, (661) 275-6021)

Dr. Gregory Ruderman was recently named chairman of the JANNAF Modeling and Simulation Subcommittee (MSS)

DR. RUDERMAN NAMED JANNAF SUBCOMMITTEE CHAIRMAN: The Propulsion Directorate's Dr. Gregory Ruderman was recently named chairman of the JANNAF[‡] Modeling and Simulation Subcommittee (MSS). He was confirmed for this position at the 53rd JANNAF Propulsion Meeting/2nd Liquid Propulsion

[‡] JANNAF = Joint Army-Navy-NASA-Air Force

Subcommittee (LPS)/1st Spacecraft Propulsion Subcommittee (SPS) Joint Meeting held in Monterey, California, in December 2005. JANNAF promotes and facilitates the exchange of technical information, establishes standards, and coordinates research, exploratory development, and advanced development programs in the areas of missile, gun, and space propulsion. The Modeling and Simulation Subcommittee covers a wide range of activities under the JANNAF umbrella. Some of these activities include: virtual engineering; integration of propulsion components and integration of propulsion systems with other vehicle systems; uncertainty assessment and management; and integrated health management (IHM). Modeling and simulation ranges from hard computing to soft computing to knowledge-based computing involving simulations of ground-based testing to sub-scale and flight-testing. (Dr. G. Ruderman, AFRL/PRSB, (661) 275-5332)

STUDENT RESEARCHER EARNS BEST PAPER AWARD: Mr. Dustin Davis, a Propulsion Directorate on-site contractor with ERC, Inc., was recently honored by the JANNAF Liquid Propulsion Subcommittee (LPS). Mr. Davis won the LPS Best Student Paper Award at the 2nd JANNAF LPS Technical Meeting held in Monterey, California, in December 2005. He was recognized for his paper entitled, "Experiments on a Coaxial Injector Under an Externally-Forced Transverse Acoustic Field," which was co-authored by Dr. Bruce Chehroudi of ERC, Inc. and Dr. Doug Talley of AFRL/PR's Space and Missile Propulsion Division (AFRL/PRS). The paper was presented in the technical session on Injectors and Wall Heat Flux. (Mr. D. Davis, AFRL/PRSA (ERC), (661) 275-5817)